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वस्त्रादि–उच्च तापमान पर कृत्रिम प्रकाश के प्रति रंग का पक्कापन ज्ञात करने की पद्धति–जीनॉन आर्क फेडिंग लैम्प परीक्षण

Indian Standard

TEXTILES—METHOD OF TEST FOR DETERMINATION OF COLOUR FASTNESS OF TEXTILE MATERIALS TO ARTIFICIAL LIGHT AT HIGH TEMPERATURES—XENON ARC FADING LAMP TEST

ICS 59.080.01

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NEW DELHI 110002

September 2002 **Price Group 7**

Chemical Methods of Test Sectional Committee, TX 05

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Chemical Methods of Test Sectional Committee had been approved by the Textile Division Council.

This standard is intended to provide a test method for determination of colour fastness of textile materials to artificial light at high temperature generally encountered in the interiors of motor vehicles.

There also exists IS 2454 : 1985 'Methods for determination of colour fastness of textile materials to artificial light (xenon lamp) (*first revision*)' on the subject.

This standard is technically equivalent to ISO 105-B06:1988 'Textiles—Tests for colour fastness—Part B06 Colour fastness to artificial light at high temperature: Xenon arc fading lamp test' issued by the International Organization for Standardization.

The composition of the Committee responsible for formulation of this standard is given in Annex E.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off' numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

TEXTILES—METHOD OF TEST FOR DETERMINATION OF COLOUR FASTNESS OF TEXTILE MATERIALS TO ARTIFICIAL LIGHT AT HIGH TEMPERATURES—XENON ARC FADING LAMP TEST

1 SCOPE

1.1 This standard specifies a method for determining the resistance of colour of textiles of all kinds and in all forms to the action of artificial light representative of natural daylight and to the simultaneous action of heat. Of the five different sets of exposure conditions specified (*see* **4.3**), four use D65 and the fifth a somewhat lower cut-off wave length. The test method gives special consideration to the light and heat conditions which occur in the interior of a motor vehicle.

1.2 The method employs two sets of blue wool references. The results from the two sets of references need not necessarily be same.

1.3 The five different sets of conditions specified are known to give similar, but not necessarily identical results.

2 REFERENCES

The following Indian Standards contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
686 : 1985	Method for determination of colour fastness of textile materials to daylight *(first revision)*
768 : 1982	Method for evaluating change in colour *(first revision)*
2454 : 1985	Methods for determination of colour fastness of textile materials to artificial light (xenon lamp) (*first revision*)
10251 : 1982	General principles of testing textiles for colour fastness tests

3 PRINCIPLE

A specimen of the textile is exposed to artificial light under prescribed conditions, along with blue wool references. The colour fastness is assessed by comparing the change in colour of the specimen with that of the references used or with the grey scale after the specimen has been exposed to a specified amount of radiant energy.

4 REFERENCE MATERIALS AND APPARATUS

4.1 Reference Materials

Two sets of blue wool references are used and are not interchangeable.

4.1.1 *References* 1 to 8

Blue wool references developed and produced in Europe are identified by the numerical designations 1 to 8. These references are blue wool cloths dyed with the dyes listed in Table 1. They range from 1 (very low colour fastness) to 8 (very high colour fastness) so that each higher-numbered reference is approximately twice as fast as the preceding one (*see* Table 1).

4.1.2 *References L2 to L9*

Blue wool references developed and produced in the United States are identified by the letter *L* followed by the numerical designation 2 to 9. These eight references are specially prepared by blending varying proportions of wool dyed with CI Mordant Blue 1 (Colour Index, Third edition, 43830) and wool dyed with CI Solubilized Vat Blue 8 (Colour Index, Third edition, 73801), so that each higher-numbered reference is approximately twice as fast as the preceding reference.

Table 1 Dyes for Blue Wool References 5 to 8

(References 1 to 4 are not applicable to this test)
(*Clause* 4.1.1)

Sl No. (1)	Reference No. (2)	Dye (Colour Index Designation) (*see* Note) (3)
i)	5	CI Acid Blue 47
ii)	6	CI Acid Blue 23
iii)	7	CI Solubilized Vat Blue 5
iv)	8	CI Solubilized Vat Blue 8

NOTE — The Colour Index (Third edition) is published by the Society of Dyers and Colourists, P.O. Box 244, Perkin House, 82 Grattan Road, Bradford BD1 2JB, West Yorkshire, United Kingdom, and by the American Association of Textile Chemists and Colourists, P.O. Box 12215 Research Triangle Park, North Carolina 27709, U.S.A.

4.1.3 *Humidity Test Control*

The humidity test control is a red azoic dyed cotton cloth (*see* IS 2454). This control is used only for those exposure conditions specified in **4.3.2**.

4.2 Apparatus

4.2.1 *Xenon Arc Lamp Apparatus—Either Air-Cooled or Water-Cooled*

The specimens and the references are exposed in one of the two types of apparatus (*see* **4.2.1.1** and **4.2.1.2**). The variation of the light intensity over the area covered by the specimens and references shall not exceed ±10 percent of the mean.

The distance from the surface of the specimen and that of the references to the lamp shall be the same.

4.2.1.1 Air-cooled xenon arc lamp apparatus (*see* Annex A) consisting of the following elements:

a) *Light source*—in a well ventilated exposure chamber.

The light source shall consist of one or more xenon arc lamps, the number and size of which will depend on the type of apparatus used (*see also* **A-1**).

b) *Light filter*—placed between the light source and the specimens and references so that the ultraviolet spectrum is steadily reduced.

The transmission of the filter used shall be at least 90 percent between 380 nm and 750 nm. For apparatus with absorbing filters, the transmission shall fall to 0 percent between 310 nm and 320 nm (*see* **A-1**). For apparatus with absorbing and reflecting filters, a filter system shall be used so that the radiation at the specimen has a lower spectral cut-off value approximately equal to that of window glass (*see* **A-1**).

c) *Heat filter*—The spectrum of the xenon arc contains an appreciable amount of infra-red radiation which shall be reduced by absorbing filters or a filter system consisting of an inner quartz cylinder with an infra-red reflecting layer, an outer quartz cylinder and a water jacket between the inner and outer quartz cylinders (*see* **A-1**).

d) *Humidity test control*—The effective humidity at the surface of the specimens is low. In accordance with IS 2454, the colour fastness of the humidity test control shall be ≥6, when obtained with blue wool references 5 to 8.

4.2.1.2 Water-cooled xenon arc lamp apparatus (*see* Annex B) consisting of the following elements:

a) *Light source*—in a well ventilated exposure chamber.

The light source shall consist of a xenon arc lamp, the size of which will depend on the type of apparatus used (*see also* **B-1.1**).

b) *Light filters*

1) *Set of conditions No.3*—Inner and outer glass filters as specified in **4.3.3** to contain and direct the flow of cooling water. An inner filter of Pyrex (borosilicate) glass and

an outer filter of clear (soda lime) glass shall be used so that the radiation at the specimen has a lower spectral cut-off value approximately equal to that of window glass (*see also* **B-1.2**).

2) *Set of conditions No.5*—Cylindrical quartz inner filter and type "S" high-borate borosilicate glass outer filter that provide a UV cut-off at approximately 275 nm, which is somewhat below that of natural daylight are used. This set is used to accelerate the rate of colour change (*see also* **B-1.2**).

c) *Heat filter*

Distilled or deionized water circulating through the lamp assembly between the inner and outer glass filters, cooled by passage through a heat-exchange unit.

If a glass or water filter is used to eliminate excess infra-red radiation so as to meet the temperature conditions specified in **4.3**, frequent cleaning shall be carried out to avoid unwanted filtering caused by dirt (*see also* **B-1.4**).

d) *Monitoring/Controlling radiometer*

Since the irradiance at the surface of the specimen may vary as a function of lamp intensity and lamp-to-specimen distance, uniformity of exposure shall be controlled by a monitoring radiometer which permits exposure to specified levels of irradiation (incident energy per unit area) at a point in the plane of the specimen rack (*see* **C-1**).

4.2.2 *Opaque Cardboard,* of low sulphur content and free from fluorescent brightening agents, or other thin opaque material, partially covering the specimens and references.

4.2.3 *Temperature Sensors*

4.2.3.1 *Black-standard thermometer (BST) (for sets of conditions* 1 *to* 4)

The black-standard thermometer consists of a plain stainless-steel plate, measuring about 70 mm × 40 mm and with a thickness of about 0.5 mm, whose temperature is measured by a resistance thermometer with good heat-conducting properties fitted to the reverse side. The metal plate is fixed to a plastics plate so that it is thermally insulated. It is coated with a black layer which has an absorption of at least 95 percent even in the infra-red region.

4.2.3.2 *Black-panel temperature-sensing device (for set of conditions No.* 5)

The black-panel sensing device shall be a 70 mm × 150 mm × 0.95 mm stainless-steel panel to which is fastened a resistance thermometer element whose sensitive portion is centered both horizontally and vertically on the panel, the entire system being covered with a non-selective, infra-red absorbing black finish. The black finish shall have at least 95 percent absorbance. The side of the panel not facing the light source shall not be thermally insulated.

4.2.4 *Grey Scale for Assessing Change in Colour,* complying with the requirements of IS 768.

4.3 Exposure Conditions

Apparatus with absorbing filters.

4.3.1 *Set of Conditions No.* 1

Air-cooled 4 500 W xenon arc lamp with four heat-absorbing filters and three window-glass filters, uniformly distributed on filter lantern.

Specimens and references facing light source:

Temperature in test chamber	: 45° ± 5° C
BST temperature	: 115° ± 3° C
Relative humidity in test chamber	: 20 ± 10 percent

4.3.2 *Set of Conditions No.* 2

Air-cooled 4 500 W xenon arc lamp with four heat-absorbing filters and three window-glass filters, uniformly distributed on filter lantern.

Specimens and references placed in upper half of sample holders, which turn 180° about their longitudinal axis after each revolution of the rack:

Temperature in test chamber	: 35° ± 5° C
BST temperature	: 82° ± 3° C
Light fastness of red azoic dyed cotton control	: ≥ 6

4.3.3 *Set of Conditions No.* 3

Water-cooled 2 500 W, 3 500 W or 6 500 W xenon arc lamp with borosilicate inner filter and soda-lime outer filter.

Specimens and references facing light source :

Temperature in test chamber : 70° ± 5° C
BST temperature : 100° ± 3° C
Relative humidity in test chamber : 20 ± 10 percent

4.3.4 *Set of Conditions No.* 4

Lamp assembly comprising three air-cooled 4 500 W xenon arc lamps with fused-quarts inner filter with IR-reflecting layer, fused-quartz outer cylinder (with water between the inner filter and outer cylinder) and three additional sectional filters made of special UV glass (two filters) and window-glass (one filter).

Specimens and references facing light source :

Temperature in test chamber : 60° ± 5° C
BST temperature : 100° ± 3° C
Relative humidity in test chamber : 20 ± 10 percent

4.3.5 *Set of Conditions No.* 5

Water-cooled 3 500 W or 6 500 W xenon arc lamp with quartz inner filter and Type S high-borate borosilicate outer filter.

Specimens and references facing light source:

Alternating 'light on' and 'light off' periods (3.8 h light on/1 h light off) giving the conditions specified in Table 2.

5 TEST SPECIMENS

The size of the test specimens shall depend on the number of specimens to be tested and on the shape and dimensions of the specimen holders supplied with the apparatus.

5.1 In apparatus of the air-cooled type, an area of the textile measuring not less than 45 mm × 20 mm is usually used. The specimen may be a strip of fabric, yarns wound close together on a card or laid parallel and fastened to a card, or a mat of fibres combed and compressed to give a uniform surface and fastened to a card. Each exposed area and each unexposed area shall be not less than 20 mm × 20 mm.

NOTE—The specimens may also be tested underlaid with the substrate material to be used or with other materials to be agreed upon. In this case, the maximum thickness of the underlaid material shall be 5 mm. The blue wool references shall not be underlaid with these materials (care shall be taken to avoid using foams which deteriorate chemically under the test conditions).

5.2 To facilitate handling, the specimens to be tested and the references may be mounted on one or more cards as indicated in Figs. 1 and 2.

5.3 In apparatus of the water-cooled type, specimen holders are fitted to take specimens measuring approximately 70 mm × 120 mm. When desired specimens of different sizes to fit alternative sizes of specimen holder may be used. Specimens may be mounted on white cardboard, but *L* references shall always be exposed on a white cardboard backing.

5.4 The covers (*see* **4.2.2**) shall make close contact with the surface of the unexposed areas of the specimens and the references, in order to give a sharp line of demarcation between exposed and unexposed areas, but shall not compress the specimen unnecessarily.

Table 2 Exposure Cycle for Set of Conditions No. 5

(*Clause* 4.3.5)

Sl No. (1)	Parameter (2)	'Light On' Period (3)	'Light Off' Period (4)
i)	Irradiance level	0.55 W/m² + 0.01 W/m² at 340 nm	—
ii)	Black-panel temperature	89° + 2°C	38° + 2°C
iii)	Dry-bulb temperature	63° + 2°C	38° + 2°C
iv)	Relative humidity, percent	50 ± 10	95 ± 5
v)	Conditioning—water temperature	63° + 4°C	40 + 4°C

NOTE—Start the exposure at the beginning of a 3.8 h 'light on' period (*see* **C-2**).

5.5 The specimens and references shall be of equal size and shape in order to avoid errors in assessment due to over-rating the visual contrast between exposed and unexposed parts on the larger pattern as against the narrower references [*see* **7.1** (c)].

5.6 When testing pile fabrics, the surface of the pile fabric shall be arranged in such a way that the specimens are at the same distance from the light source as the references. Covers for the unexposed portions shall avoid surface compression.

6 PROCEDURE

6.1 Adjustment of Humidity (*see* 4.2.1.1 and 4.2.1.2)

6.1.1 Check that the apparatus is in good running order and that it is equipped with a clean xenon burner tube (follow the manufacturer's directions and *see* Annex A and Annex B).

6.1.2 *Set of Conditions No.* 2

Place a portion of the humidity test control measuring not less than 45 mm × 20 mm, together with the blue wool references, on to a card, if possible in the middle area of the specimen holder (*see* **5.2**).

6.1.3 Place the filled specimen holders on the specimen rack of the apparatus, with the holders supported both top and bottom and in proper vertical alignment. All spaces in the specimen rack not filled with specimens shall be filled with holders containing white cardboard.

6.1.4 Operate the apparatus continuously until a test is completed unless the lamp requires cleaning or the burner, outer filter or inner filter requires changing because it has reached the maximum number of hours of a recommended usage.

6.1.5 For set of conditions No. 2 expose the partially covered strip of the humidity test control and the references simultaneously until a contrast between the exposed and unexposed portions equal to Grade 4 on the grey scale is produced on the humidity test control.

6.1.6 For set of conditions No. 2 assess the colour fastness of the humidity test control at this stage and, if necessary adjust the controls on the apparatus to give the selected exposure conditions. Check daily and, when necessary, re-adjust the controls to maintain the specified black-standard temperature and humidity [*see* **4.2.1.1**(d) and **4.2.1.2**(d)].

6.2 Exposure Methods

Expose the specimen (or group of specimens) and the required references simultaneously under the desired conditions, in such a manner and for such

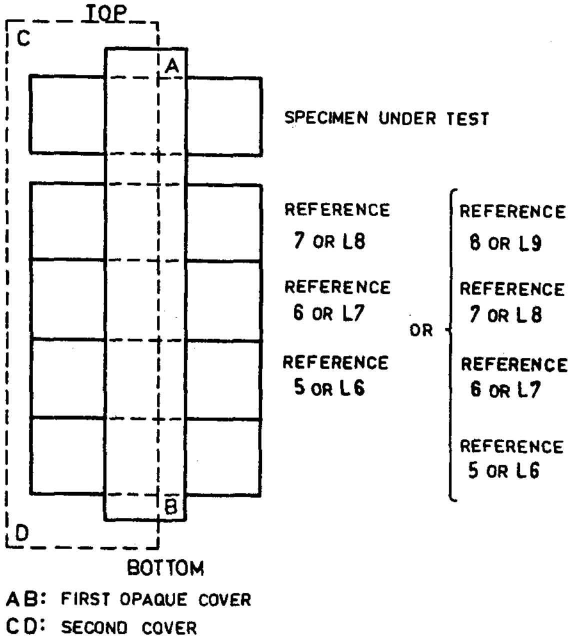

FIG. 1 MOUNTING FOR METHOD 1

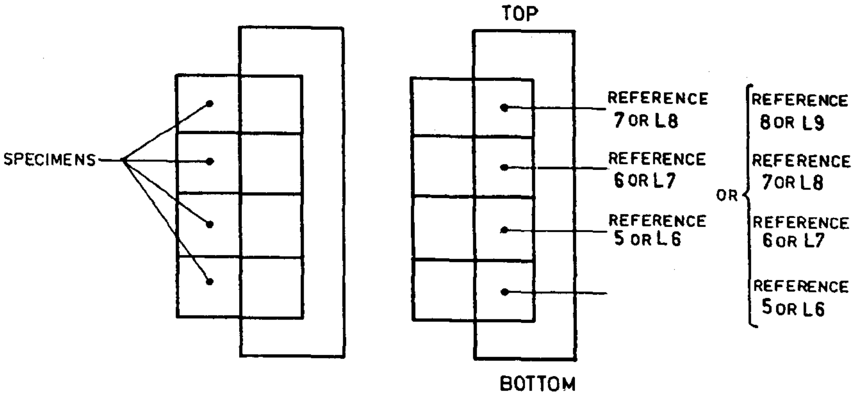

FIG. 2 MOUNTING FOR METHOD 2

time as is necessary to evaluate fully the colour fastness of each specimen relative to that of the references by progressively covering both the specimens and exposed references during the test (Method 1).

6.2.1 *Method* 1

End point determined by colour change in the specimen.

6.2.1.1 This method is considered the most satisfactory and shall be used in cases of dispute over the numerical rating. The basic feature is the control of the exposure periods by inspection of the specimen and, therefore, one set of references is required for each specimen under test.

6.2.1.2 Arrange the specimen to be tested and the references as shown in Fig.1 with an opaque cover *AB* across the middle third of the specimen and references. Expose to the xenon arc light under the conditions enumerated in **4.2.1.1** and **4.2.1.2**. Follow the effect of light by removing the cover periodically and inspecting the specimen.

6.2.1.3 Expose until the contrast between the exposed and the unexposed portions of the specimen is equal to Grade 4 on the grey scale. Cover the left-hand third of the specimen and references with an additional opaque cover (*see* *CD* in Fig.1).

6.2.1.4 Continue to expose until the contrast between the fully exposed and unexposed portions of the specimen is equal to Grade 3 on the grey scale.

6.2.1.5 If reference 7 or *L*8 fades to a contrast equal to grey scale Grade 4 before the specimen does, the exposure is terminated at this stage. When a specimen has a colour fastness equal to or greater than 7 or *L*8, it would require unduly long exposure to produce a contrast equal to grey-scale Grade 3; moreover, this contrast would be impossible to obtain when the colour fastness is 8 or *L*9. Assessments in the region of 7 to 8 or *L*8 to *L*9 are made, therefore, when the contrast produced on reference 7 or *L*8 is equal to grey-scale grade 4, the time required to produce this contrast being long enough to eliminate any error which might result from inadequate exposure.

6.2.2 *Method* 2

End point determined by comparison with a specified minimum-performance reference.

The main feature of this method is the control of exposure by inspection of the reference corresponding to the specified colour fastness of the specimen. This method is used to check conformity with a performance specification. The specimens are exposed with three (or four) references; the one specified as the minimum, the one immediately above it on the scale and the one immediately below it (*see* Fig.2). If the performance specification states, for instance, a minimum colour fastness rating of 6, the samples and reference are exposed until a contrast equal to Grade 3 on the grey scale is detected on reference 6. Other minimum fastness ratings can also be checked, the test procedure being adjusted to the particular requirement.

6.2.3 *Method* 3

End point based on radiant energy

Expose the specimens (*see* **C-1**) to a specified level of radiant exposure at a central wavelength of

340 nm. The exact level of radiant exposure will depend on the material and the application and shall be agreed on by the interested parties.

7 ASSESSMENT OF FASTNESS TO LIGHT

7.1 Remove all the covers, thus revealing on specimens and references one or two areas, depending on the method used, which have been exposed for different times, together with at least one area which has not been exposed to light. After exposure, condition specimens for at least 24 h at a temperature of 20°C and a relative humidity of 65 percent. Compare, under suitable illumination (*see* IS 10251), the changes in each specimen with the relevant changes in the references as described below for each method. Compare in each case the exposed area of the specimen with the unexposed area of the specimen or, alternatively, with a piece of the original specimen.

a) *Assessment after testing by Method* 1

The colour fastness of a specimen is the number of the reference which shows similar changes in colour corresponding to Grade 4 and/or Grade 3 on the grey scale for assessing change in colour if the specimen shows changes in colour which are nearer to the imaginary midway between any two consecutive references, the intermediate rating, for example 5-6 or *L*4-*L*5, shall be given. If different assessments are obtained at the different degrees of contrast, the colour fastness of the specimen is the arithmetic mean of these assessments expressed to the nearest half or whole grade. Assessments shall be confined to whole or midway ratings only. When the arithmetic mean gives a quarter or three-quarter rating, the assessment is defined as the next higher half or whole grade.

b) *Assessment after testing by Method* 2

Exposures based on a performance specification (*see* **6.2.2**) shall be assessed by comparison of the colour changes in the specimen and the minimum performance reference. If the specimen shows a greater change in colour than the performance reference, the colour fastness shall be classified as 'satisfactory'; if the specimen shows a greater change in colour than the performance reference, the colour fastness shall be classified as 'unsatisfactory'.

c) *Assessment after testing by Method* 3

Note any change in colour (*see* **7.5**). Visual comparisons may be made using the grey scale for assessing change in colour. If the specimens have a backing material, note if there is any increase in the stiffness of the backing.

7.2 Comparison of the changes in each specimen with the changes in the references may be facilitated by surrounding the specimen with a mask of neutral grey colour approximately midway between the lighter chips in Grades 1 and 2 (approximately Munsell N5) and surrounding the reference in turn with a similar mask of equal aperture.

7.3 However, to avoid migrating the colour fastness of the specimen due to photochromism, the specimen shall be allowed to condition in the dark at room temperature for 24 h before the colour fastness is assessed (*see* Annex D).

7.4 If the specimen is photochromic, the colour fastness rating shall include a P bracketed with the rating obtaining from the test for photochromism, for example 6 (P3-4) (*see* Annex D).

7.5 The term 'change in colour' includes changes in hue, depth, brightens or any combination of these characteristics (*see* IS 768).

8 TEST REPORT

Report the apparatus, the method and the set of exposure conditions used the structure of the specimen, particularly the type of underlay and whether the exposed area of the specimen was compared with the unexposed area or with a piece of the original specimen, plus the following information as appropriate:

a) *Method* 1

The numerical rating for the colour fastness to light. Express the fastness rating as the number alone (when using the references designated 1 to 8) or as the number together with the prefix *L* (when using the references designated *L*2 to *L*9).

b) *Method* 2

The classification 'satisfactory' or 'unsatisfactory' and the performance reference.

c) *Method* 3

1) The following conditions of exposure:
    - i) The type of exposure instrument used;
    - ii) The operating-cam number;
    - iii) Details of the exposure (light/dark) cycle;
    - iv) Details of the lamp inner and outer filters;
    - v) Details of the light period: irradiance, black-panel temperature, relative humidity;
    - vi) Details of the dark period: black-panel temperature, relative humidity;
    - vii) The total radiant-energy exposure, in kilojoules per square metre;
    - viii) The exposure time, in hours; and
2) The colour difference as a grey scale rating.

ANNEX A

(*Clauses* 4.2.1.1 *and* 6.1.1)

APPARATUS FOR DETERMINING COLOUR FASTNESS WITH AIR-COOLED XENON ARC LAMPS

A-1 The test apparatus is equipped with one or more air-cooled xenon arc lamps of two types as the source of radiation. There are two different models of the apparatus of 1 500 W or 4 500 W. the xenon arc lamp is surrounded by a filter system consisting of a quartz inner cylinder, an additional lamp-chimney comprising a combination of heat/window-glass filters and an outer cylinder of special, ultraviolet glass.

Another model of exposure apparatus is equipped with three air-cooled xenon arc lamps with a wattage of 4 500 W each. The xenon arc lamps are arranged radially in symmetrical fashion about a central cooled heat-absorber system with reflecting filters. This system is surrounded by a filter system consisting of an inner quartz cylinder with an infra-red-reflecting layer, an outer quartz cylinder, a water jacket between the inner and outer quartz cylinders, as well as additional outer cylindrical filter comprising three partial covers (combination of ultraviolet special glass and window-glass). In each of the models of the exposure apparatus, the diameter of the specimen rack, lamp size and lamp wattage are selected so that, when the specimens are exposed in the holders, the irradiant at the surface of the specimens is at the appropriate level.

A-2 The space between the xenon arc lamp and the filtering device is cooled by a current of air. This cooling air should be discharged outside the building.

A-3 The decrease in light intensity due to ageing of air-cooled xenon arc lamps is small. As a result, it is only necessary to replace the burner after 1 500 operating hours. In apparatus with three xenon arc lamps, the burners shall be exchanged in rotation. Some types of apparatus are additionally equipped with an automatic irradiance control facility. The burners shall be discarded when the appropriate irradiance level can no longer be reached under automatic control.

The change in the transmission properties of the heat and window-glass filters due to ageing can be eliminated almost entirely by replacing the oldest filter every 500 h .

A-4 The specimen holders are mounted on a revolving rack and at a fixed distance from the vertical lamp unit. Depending on the model of apparatus, the specimen holders may be mounted either vertically or inclined in the rack, and the rack may be rotated at between 2 rpm and 5 rpm around the lamp unit. Depending on the test conditions, the specimen holders may be turned 180° about their longitudinal axis after each revolution of the rack.

A-5 A stream of air generated by a blower is directed through the test chamber and over the surface of the test specimens. In the case of the apparatus with a 1 500 W xenon arc lamp, the test chamber is air-conditioned by adding moisture to the air using spray jets or by means of an ultrasonic humidifier unit, whilst, in the case of the apparatus with one or three 4 500 W xenon arc lamps, water is atomized by an aerosol device and fed into the air stream. The relative humidity in the test chamber hygrometer.

A-6 The exposure conditions, relative to the effective moisture, laid down in present specifications are achieved in the test apparatus by regulating the relative humidity of the air within certain limits, which are given in the instructions for using the apparatus.

The test-chamber temperature and black-standard temperature can be influenced by regulating the air supply. In the case of the apparatus with one or three 4 500 W xenon arc lamps, it is possible, by connecting to a heating and/or cooling device, to control the test-chamber temperature over a wide range. In some types of apparatus, the temperature is controlled using a black-standard thermometer.

A-7 Apparatus for use in this test method is equipped with a countdown switch which controls the length of exposure. Some types of apparatus are additionally equipped with a radiometer (broadband UV:300 nm to 400 nm) designed to switch off the apparatus as soon as a given radiant exposure level has been reached.

ANNEX B

(*Clauses* 4.2.1.2 *and* 6.1.1)

APPARATUS FOR DETERMINING COLOUR FASTNESS WITH WATER-COOLED XENON ARC LAMPS

B-1 DESCRIPTION AND CONDITIONS OF USE

B-1.1 The test apparatus employed utilizes a long-arc water-cooled xenon arc lamp as the source of radiation. While all of the xenon arc lamps employed are of the same general type, different-size lamps operating in different wattage ranges are employed in several of the different sizes and types of apparatus . In each of the various models of exposure apparatus, the diameter of the specimen rack, lamp size and lamp wattage can be varied so that, when the specimens are exposed in the holders, the irradiance at the face of the specimens is at the appropriate level.

B-1.2 The xenon arc lamp used consist of a xenon burner tube, inner glass filter, outer glass filter and the necessary accessories. For colour-fastness tests, a borosilicate glass (Corning 7740) inner filter and a soda-lime glass (Kimble R6) outer filter are used so that the irradiation at the specimen has a lower spectral cut-off value approximately equal to that of window-glass. Other glass filters are available with different spectral cut-off values, but these shall not be used for colour-fastness tests. Because of transmission changes (polarization), outer filters shall be discarded after 2 000 h of use and inner filters after 400 h of use. Because of a drop in intensity with continued use, xenon burners shall be discarded when 1.0 W/(m^2.nm) at 420 nm is no longer achievable by automatic control.

B-1.3 All xenon arc exposure apparatus is equipped with suitable starters, reactance transformers and indicating and control equipment for either manually or automatically controlling the wattage of the lamp may require periodic adjustment to maintain 1.0W/(m^2.nm) at 420 nm.

B-1.4 To cool the lamp, distilled or deionized water is circulated through the lamp assembly at a minimum flow rate of 378.5 l/h. To prevent contamination and minimize the formation of deposits, the water is polished by the use of a mixed-bed deionizer just ahead of the lamp. The recirculated lamp water is cooled without contaminating it by the use of a heat-exchange unit employing either tap water or refrigerant as the heat-transfer medium.

B-2 TEMPERATURE AND HUMIDITY CONTROL

B-2.1 Because of the sensitivity to temperature of some fabrics, accurate, close control of the test temperature is extremely important in tests made by this procedure. The temperature is measured and controlled using either a black-standard thermometer or a black-panel thermometer, which is mounted on the revolving specimen rack so that its surface is in the same relative position and subjected to the same influences as the test specimens.

B-2.2 The exposure apparatus is enclosed in an insulated cabinet to minimize the effect of any variation at room temperature. A ventilation system provides a constant stream of air through the test chamber and over the test specimens. The temperature of the air is automatically controlled by re-circulating warm air from the test chamber mixed with cooler room air.

It may be necessary to adjust the fan speed to meet both the specified black-panel temperature and the specified dry-bulb temperature.

B-2.3 The specimen holders are supported by vertical or inclined cylindrical frame or rack which is rotated at 1 rpm around the lamp which is centered both horizontally and vertically with respect to the exposure area in the sample holders (*see* **B-1**).

B-2.4 Apparatus for use in this method is equipped with a countdown timer for controlling the length of exposure. Some apparatus is also equipped with a light monitor designed to switch off the apparatus as soon as a given radiant exposure has been achieved.

ANNEX C

[*Clause* 4.2.1.2(d) and *Table* 2]

INFORMATION ON PERFORMING THE TEST

C-1 MONITORING/CONTROLLING RADIOMETER

A radiometer employing a narrow-bandpass interference filter restricting measurement to the UV spectral region has been used satisfactorily. It consists of a sensor employing a photodetector and an interference filter with a central-wavelength tolerance not greater than 2 nm, and a half-bandwidth not greater than 20 nm.

Single-or multiple-filter radiometers capable of measuring, recording, controlling and/or integrating irradiance with respect to time are satisfactory.

For monitors designed to automatically maintain a constant level of irradiance, exposures of equal time should provide equivalent irradiation, Q, which may be calculated by the following formula:

$$Q = E \times 3.6 \times t$$

where

Q = irradiation, expressed in kilojoules per square metre;

E = irradiance, expressed in watts per square metre (or joules per square-metre-second);

t = time, expressed in hours; and

3.6 = conversion factor, expressed in kilo-seconds per hour.

Single-filter radiometers equipped with a pre-settable countdown integrator calibrated in kilojoules per square metre, designed for use with the exposure apparatus, can be used to terminate the test when the specimens have received the required level of irradiation.

The radiometer shall have means, provided by the manufacturer, for checking the calibration, or calibration shall be certified by the manufacturer for a specified time interval when the apparatus is used in the manner described herein.

C-2 SETTING UP THE APPARATUS

To ensure repeatability of tests, maintain and calibrate the apparatus to the manufacturer's specifications.

Remove and cap the specimen spray unit. While the specimen spray can be turned off by means of a switch on the control panel, it is recommended that the specimen spray assembly be removed and the pipe capped to prevent accidental spraying of the test specimens.

Turn off the rack spray unit with the valve provided.

Fit the xenon arc burner with a quartz inner filter and type 'S' high borate borosillicate outer filter.

Set the operation switches as follows:

Wattage adjustment : automatic
Countdown switch : irradiation
Lamp ignition : on
Fixed-air valve : off
Humidifier : on
Water heater : on
Air heater : on
Specimen spray : off
Rack spray : off

Set the thumb-wheel controls as follows:

	Light Period	*Dark Period*
Automatic irradiance	0.55W/m^2 at 340 nm	–
Black-panel temperature	89°C	38°C
Wet-bulb depression	13°C	0°C
Conditioning-water temperature	63°C	40°C

Set the air-heater cycle selector switch to light/dark cycle and install a 60 cam which provides 3.8 h of light and 1.0 h of darkness.

Set the temperature of the lamp cooling water at 60°C and the high-temperature cut-out at 70°C. Adjust the temperature as necessary to provide sufficient lamp cooling but prevent condensation from forming on the lamp assembly.

It may be necessary to adjust the fan speed to meet both the specified black-panel temperature and the specified dry-bulb temperature.

Inspect the wet-bulb wick weekly, and replace it if it is discoloured or mineral deposits are observed.

C-3 USABLE POSITIONS ON THE RACK

On two-tier inclined racks with eight specimen locations, exclude the extreme top and bottom locations.

C-4 POSITIONING OF REFERENCES

Place the references in the centre of the rack on either side of the black-panel thermometer.

C-5 USE OF REFERENCES FOR STATISTICAL PROCESS CONTROL

Expose an *L*2 blue wool reference daily, from Monday to Thursday, to 37.6 kJ/m^2 at 340 nm. This exposure should produce a colour change equivalent to between step 2 and step 1-2 on the grey scale or a ΔE value[1] of 9.0 ± 0.5 when measured instrumentally. Laboratories that do not operate on a seven-day basis shall on Friday, expose an *L*4 reference to 112.8 kJ/m^2 at 340 nm in order to span the weekend. This exposure should produce a colour change equivalent to step 2 on the grey scale or a ΔE value[1] of 6.7 ± 0.5 when measured instrumentally. At least once a week, expose a blue wool 3 reference to 37.6 kJ/m^2 at 340 nm as a check on both the irradiance and heat experienced by the test specimens (tolerances will be added as data becomes available).

If, after exposure to the level of irradiation specified, the respective blue wool references do not produce the given colour change, do not resume the test until the reason has been determined and the problem resolved.

A chart recording the variation in colour change of the reference from day-to-day can be used to demonstrate process capability.

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[1] CIELAB(1976) Illuminant D_{65}, 10° observer.

ANNEX D

(*Clauses* 7.3 *and* 7.4)

METHOD OF TEST FOR DETECTION AND ASSESSMENT OF PHOTOCHROMISM

D-1 PRINCIPLE

A specimen of the textile is exposed to light of high intensity for a time much shorter than that necessary to cause a permanent change. The change in colour of the specimen is assessed immediately after exposure using the grey scale. The specimen is then stored in the dark and assessed again.

D-2 REFERENCE MATERIALS AND APPARATUS

D-2.1 Reference Materials

The references used for this test are References 1 and *L*2 as specified in IS 686.

D-2.2 Apparatus

D-2.2.1 *Light Source,* a xenon arc lamp of correlated colour temperature 5 500 K to 6 500 K.

D-2.2.2 *Filter* — A filter is placed between the light source and the specimens and references so that the ultra-violet spectrum is steadily reduced. The transmission of the glass shall be at least 90 percent between 380 nm and 750 nm, falling to 0 percent between 310 nm and 320 nm.

D-2.2.3 Opaque cardboard, or other thin opaque material, for example thin sheet of aluminium, or cardboard covered with aluminium foil or in the case of pile fabrics, a cover that avoids surface compression.

D-2.2.4 *Grey Scale for Assessing Change in Colour,* complying with IS 768.

D-3 TEST SPECIMEN

D-3.1 An area of the textile not less than 10 mm × 45 mm is required. The specimen may be a strip of cloth, yarns wound close together on a card or laid parallel and fastened on a card, or a mat of fibres combed and compressed to give a uniform surface and fastened on a card.

D-3.2 To facilitate handling, the specimen and a similar strip of the reference may be mounted on cards.

D-4 PROCEDURE

D-4.1 Cover approximately one-half of the strip of Reference 1 or Reference *L*2 with opaque cardboard (*see* **D-2.2.3**).

D-4.2 Expose the partially covered Reference 1 or Reference *L*2 continuously to the xenon arc fading lamp at moderate effective humidity until the contrast between the unexposed and the exposed portions of the reference is equal to grey scale Grade 4. Determine the time necessary to produce this change. It will only be necessary to repeat this operation if exposure conditions change significantly.

D-4.3 Cover approximately one-half of the specimen (*see* **D-3.1**) with opaque cardboard (*see* **D-2.2.3**).

D-4.4 Expose the specimen in the same position and under the same conditions as in **D-4.2** for one-quarter of the time necessary to produce a grey scale Grade 4 fade on Reference 1 or one-twenty fifth of the time necessary to produce a grey scale Grade 4 fade on Reference *L*2.

D-4.5 Remove the specimen from the source of light. Immediately remove the cover from the specimen and assess the contrast between the unexposed and the exposed portions with the grey scale.

D-4.6 If the contrast is not greater than grey scale Grade 4, the specimen is not photochromic and further examination is not necessary.

D-4.7 If the contrast between the original and the exposed portion of the specimen is greater than grey scale grade 4, leave the specimen in the dark for 1 h at 27° ± 2°C and a relative humidity of 65 ± 2 percent. If, after this period, the contrast between the unexposed and exposed portions of the specimen can still be perceived, expose the specimen to steam at atmospheric pressure to accelerate further colour restoration.

Carry out the steaming by placing the specimen on a mesh of non-corrodible material which is attached to the mouth of a 1 litre flask containing

500 ml of gently boiling water. Mount the specimen with the unexposed side facing the mesh. Steam for a period of 60 s.

D-4.8 Inspect the specimen to determine if the contrast between the unexposed and the exposed portions is still visible, and, if so, reassess the contrast between the unexposed and exposed portions of the specimen against the grey scale.

D-5 EXPRESSION OF RESULTS

D-5.1 If the specimen shows a contrast not greater than grey scale Grade 4 between the exposed and unexposed portions immediately after exposure (*see* **D-4.6**), the specimen is not photochromic; report the light fastness of the specimen in the normal manner.

D-5.2 If the specimen immediately after exposure shows a contrast between the unexposed and the exposed portions of the specimen which is greater than grey scale Grade 4 but which after conditioning according to **D-4.7** shows a difference not greater than grey scale Grade 4-5, it is photochromic.

The light fastness rating of the specimen (as determined by IS 686 or IS 2454) shall be followed by the letter P and the grey scale rating, in brackets, for example 6(P3-4), 6-7(P2-3).

D-5.3 If the contrast between the unexposed and the exposed portions of the specimen after conditioning is greater than grey scale Grade 4-5, the sample is photochromic, but is of low initial light fastness. Assess the light fastness and give the rating for the first perceptible change in brackets.

D-5.4 Temporary changes in colour which may be due to lower moisture content and/or higher temperature and whose existance can be ascertained by a hot pressing test shall not be reported as photochromic.

ANNEX E

(Foreword)

COMMITTEE COMPOSITION

Chemical Methods of Test Sectional Committee, TX 05

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(*Continued on page* 16)

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